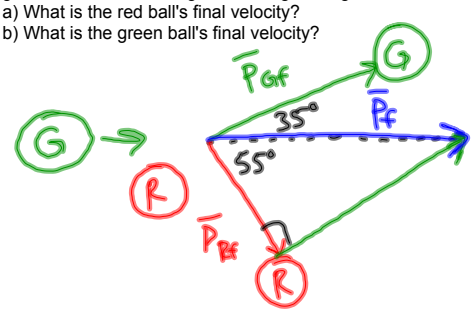
2D Collisions Practice Problems 2.9.12 Honors Physics

A green 10 kg ball moving 25 m/s hits a non-moving red 15 kg ball. After they hit, the red ball is moving to the right at a 55 degree angle from the green ball's original direction. The green ball is now moving at a 35 degree angle to the left of its original direction.
a) What is the red ball's final velocity?
b) What is the green ball's final velocity?

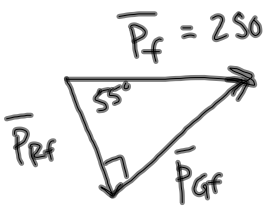


$$\bar{P}_i = \bar{P}_{Gi} + \cancel{\bar{P}_{Ri}}^{0}$$

$$= m_G \bar{V}_{Gi} = (10\,kg)(25\,m/s) = 250\,kg\cdot m/s \text{ right}$$

$$\bar{P}_i = \bar{P}_f$$

$$\bar{P}_f = 250\,kg\cdot m/s \text{ east}$$



a) Red final velocity → first find red final momentum

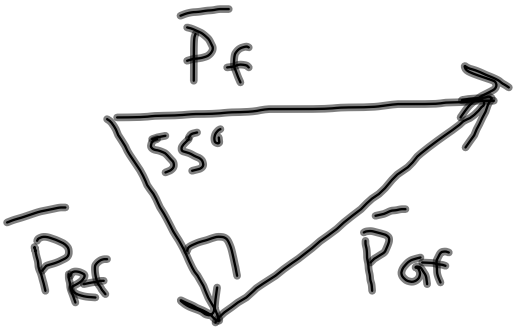
$$\cos(55°) = \frac{P_{Rf}}{P_f}$$

$$P_{Rf} = P_f \cos(55°) = (250\,kg\cdot m/s)\cos(55°)$$

$$= 143.4\,kg\cdot m/s$$

$$P_{Rf} = m_R v_{Rf}$$

$$v_{Rf} = \frac{P_{Rf}}{m_R} = \frac{143.4\,kg\cdot m/s}{15\,kg} = 9.56\,m/s$$



b) find final green velocity → first find P_{Gf}

$$\sin(55^\circ) = \frac{P_{Gf}}{P_f}$$

$$P_{Gf} = P_f \sin(55^\circ) = (250\ \text{kg}\cdot\text{m/s}) \sin(55^\circ)$$

$$= 204.8\ \text{kg}\cdot\text{m/s}$$

$$P_{Gf} = m_G v_{Gf}$$

$$v_{Gf} = 20.48\ \text{m/s}$$

Momentum

Impulse-Momentum

- Relates force, time, and change in momentum

$$\bar{F}\Delta t = m\Delta\bar{v}$$

Conservation of Momentum

Elastic Collisions

$$m_1\bar{v}_{1i} + m_2\bar{v}_{2i} = m_1\bar{v}_{1f} + m_2\bar{v}_{2f}$$

Inelastic Collisions

objects separate then come together

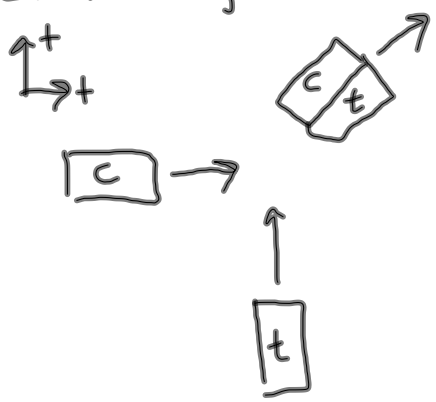
$$m_1\bar{v}_{1i} + m_2\bar{v}_{2i} = (m_1+m_2)\bar{v}_f$$

objects together, then separate

$$(m_1+m_2)\bar{v}_i = m_1\bar{v}_{1f} + m_2\bar{v}_{2f}$$

Truck traveling north at 35 m/s, $m_t = 3000$ kg

Car traveling east at 30 m/s, $m_c = 2000$ kg



find final velocity of car and truck

they collide and stick together → inelastic collision

<u>x-direction:</u>

$$\vec{P}_{ix} = \vec{P}_{cix} + \cancel{\vec{P}_{tix}}^{\,0}$$

$$\vec{P}_{ix} = \vec{P}_{fx}$$

$$\vec{P}_{fx} = \vec{P}_{cix} = m_c \vec{v}_{cix}$$

$$= (2000\text{ kg})(30\text{ m/s})$$

$$= 60\,000\text{ kg}\cdot\text{m/s}$$

<u>y-direction:</u>

$$\vec{P}_{iy} = \cancel{\vec{P}_{ciy}}^{\,0} + \vec{P}_{tiy}$$

$$\vec{P}_{iy} = \vec{P}_{fy}$$

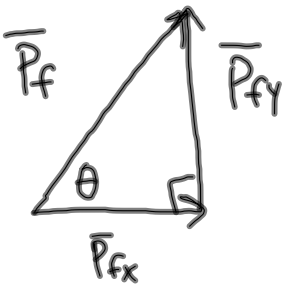
$$\vec{P}_{fy} = \vec{P}_{tiy} = m_t \vec{v}_{tiy}$$

$$= (3000\text{ kg})(35\text{ m/s})$$

$$= 105\,000\text{ kg}\cdot\text{m/s}$$

$\bar{P}_{fx} = 60000\ kg \cdot m/s$ east

$\bar{P}_{fy} = 105000\ kg \cdot m/s$ north



$$P_f^2 = P_{fx}^2 + P_{fy}^2$$

$$P_f = 120933\ kg \cdot m/s$$

$$\tan\theta = \frac{P_{fy}}{P_{fx}}$$

$$\theta = \tan^{-1}\left(\frac{P_{fy}}{P_{fx}}\right)$$

$$= 60.26^\circ$$

$$P_f = (m_c + m_t)\, v_f$$

$$v_f = \frac{P_f}{m_c + m_t}$$

$$= \frac{120933\ kg \cdot m/s}{2000\ kg + 3000\ kg}$$

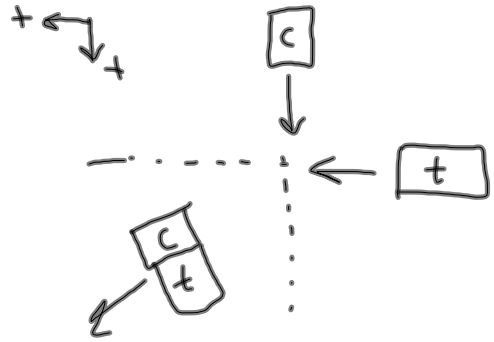
$$= 24.2\ m/s$$

$\bar{V}_f = 24.2\ m/s$ @ 60.26° N of E

Car → $m_c = 1500\ kg$ → south at $25\ m/s$

Truck → $m_t = 3500\ kg$ → west at $20\ m/s$

Find final velocity vector if the car and truck collide and stick together.



x-direction:

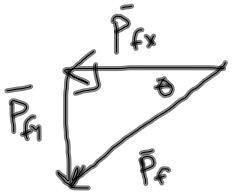
$$\bar{P}_{ix} = \bar{P}_{cix} + \bar{P}_{tix}$$

$$\bar{P}_{fx} = \bar{P}_{tix} = m_t \bar{v}_{tix}$$
$$= (3500\ kg)(20\ m/s)$$
$$= 70000\ kg \cdot m/s$$

y-direction:

$$\bar{P}_{iy} = \bar{P}_{ciy} + \bar{P}_{t\,iy}$$

$$\bar{P}_{fy} = \bar{P}_{ciy} = m_c \bar{v}_{ciy}$$
$$= (1500\ kg)(25\ m/s)$$
$$= 37500\ kg \cdot m/s$$



$$\theta = \tan^{-1}\left(\frac{P_{fy}}{P_{fx}}\right)$$
$$= 28.2°$$

Pythagorean thm. to find magnitude of $\bar{P}_f$

$$P_f = 79412\ kg \cdot m/s$$

$$v_f = \frac{P_f}{(m_c + m_t)}$$
$$= 15.9\ m/s$$